Upper Pennsylvanian Compression Floras of the 7-11 Mine, Columbiana County, Northeastern Ohio[1]

MELISSA A. MCCOMAS,[2] Department of Botany, Ohio University, Athens, Ohio 45701

ABSTRACT. Two compression floras have been discovered below the Brush Creek marine unit (lower Conemaugh) in Columbiana County, Ohio. One flora is preserved in freshwater ironstone beds 6 m below the Brush Creek and contains abundant pteridosperm and sphenopsid elements. The assemblage includes *Sphenophyllum oblongifolium, Pecopteris candolleana, Danaeites emersonii* and *Odontopteris brardii,* taxa previously recorded from younger strata. The second assemblage occurs within a 1.5-m-thick argillaceous, freshwater shale directly below the Brush Creek and yields abundant lycopod, cordaite, and conifer remains. The latter elements, some of which are permineralized with pyrite, represent the earliest occurrence of conifers in the eastern United States known to date.

OHIO J. SCI. 88 (1): 48-52, 1988

INTRODUCTION

The 7-11 strip mine exposure has provided the opportunity for several types of studies: 1) a survey of the numbers and types of taxa present in each of the floral zones; 2) the documentation of stratigraphically significant floral elements; 3) detailed floristic analysis and paleoenvironmental interpretation of the conifer-bearing strata; and 4) detailed morphological and anatomical study of conifer specimens. A summary of the first three of these studies is presented in this paper.

LOCALITY AND STRATIGRAPHY

The 7-11 strip mine is located north of East Liverpool on Ohio 7, 1.16 km north of the junction with Ohio 11 (S 1/2, NW 1/4, sec. 13, T. 10 N., R. 2 W., West Point 7 1/2' quadrangle, Madison Twp., Columbiana Co.). The freshwater units that contain the two floras are laterally confined between cross-bedded sandstones and occupy a paleotopographic low suggestive of an abandoned river channel. The freshwater deposits occur between two recognized stratigraphic markers: the Mahoning coal (Fig. 1, unit A) and the Brush Creek marine unit (Fig. 1, unit F). (Palynological assessment indicates Mahoning Coal according to R. M. Kosanke, United States Geological Survey, pers. comm.) The Mahoning coal is the earliest coal seam of the Conemaugh Group in the Appalachian Basin, and is considered equivalent to rocks of late Desmoinesian/Westphalian D age (Phillips et al. 1985). The Brush Creek is recognized as the earliest marine unit of the Conemaugh, and is considered equivalent to rocks of early Missourian/Stephanian A age (Rice et al. 1979, Phillips et al. 1985). The lower floral zone is found within ironstone interbeds located 2.4 m to 2.8 m above the coal (Fig. 1, within unit B). The upper floral zone comprises the 1.5 m of argillaceous shale directly beneath the Brush Creek unit (Fig. 1, unit E).

The Mahoning coal seam, which is being mined by open-pit methods, is overlain by a 4.1-m sequence of barren, medium-gray, argillaceous shales (Fig. 1, unit B). Nine distinct, resistant, laterally continuous,

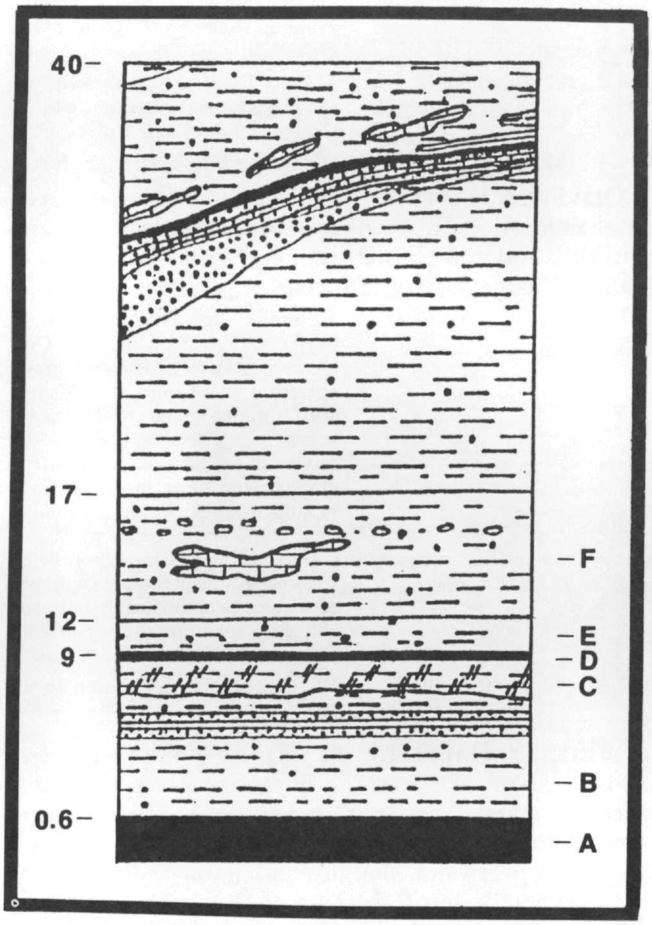

FIGURE 1. Stratigraphic section of central part of east-west exposure in 7-11 strip mine highwall, Columbiana County, Ohio. Coals are black; other strata are designated by standard lithologic symbols. Numbers at left indicate distance in meters above the mine floor. A, Mahoning Coal; B, barren shale sequence including fossiliferous, clay-ironstone interbeds; C, underclay; D, Brush Creek (?) Coal; E, fossiliferous dark shale horizon; F, Brush Creek marine unit.

clay-ironstone interbeds (ranging from 3.1-12.2 cm in thickness) occur between 0.3 and 3.8 m of the lower contact. These beds are composed of clay-siderite with small amounts of silty impurity. Fossil-bearing horizons occur within the upper 6 cm of two of the thickest ironstone units. The ironstone interbeds suggest a depo-

[1]Manuscript received 14 September 1987 and in revised form 15 January 1988 (#87-43).
[2]Present address: 1711 Seneca, Sandusky, OH 44870.

sitional setting in which low sulfide/sulfate, slightly alkaline, reducing chemical conditions contributed not only to the precipitation of $FeCO_3$ (sideritic) cement (Krumbein and Sloss 1951, Schutter 1983, and references cited therein), but in some cases to the non-decay of plant and animal material. The random vertical and horizontal orientation of plant material, as well as the excellent preservation state of the plants (i.e., entire, undamaged pinnules, large fragments of fronds, and leaves exhibiting fine details of venation), suggest a gentle settling of proximally derived plant remains into an anoxic ooze of flocculating clays.

The barren shale sequence is overlain by a 2.7-m underclay (Fig. 1, unit C) that grades upward into an 8-cm impure coal (Brush Creek coal?; Fig. 1, unit D). Noncontinuous layers of barren, limy concretions occur at two separate intervals within the underclay. Many clay specialists view underclays as soil profiles, and invoke soil processes to explain the features present (Schutter 1983, and references cited therein). The calcareous concretions have been interpreted as the rock equivalents of the caliche deposits commonly observed at the contact between weathered and unweathered clays, or at the base of the leached zone (Schutter 1983, and references cited therein). Based upon the extent of this underclay deposit and the presence of several "caliche" horizons, it is hypothesized that fine-grained flood sediments underwent several periods of exposure and deep-weathering.

The 1.5 m of finely laminated, dark gray to black organic shales that overlie the impure coal comprise the upper floral horizon (Fig. 1, unit E). The fine-grained, argillaceous matrix is suggestive of a fairly constant influx of fines into a static, low-energy environment. The entire unit is fossiliferous to varying degrees. The occurrence of abundant plant remains, permineralized by FeS_2 (pyrite), is observed in the uppermost and lowermost segments of the unit. Pyrite development generally is linked to the activity of sulfate-reducing bacteria in anoxic, acidic, organic-rich bottom sediments (Krumbein and Sloss 1951). Freshwater environments, in contrast to marine environments, generally are considered to be too poor in sulfate to produce pyrite (Schutter 1983, and references cited therein). In view of the stratigraphic position of the dark shale unit and its total lack of marine fauna, a logical inference is that underlying high-sulfur organic material provided the sulfate source for the lower permineralized zone, while the downward percolation of sulfate-rich seawater from the overlying Brush Creek marine sediments promoted pyrite development in the upper zone. The three-dimensional preservation of the specimens in these zones indicates that permineralization occurred prior to, or during, early diagenesis.

FOSSIL PLANTS

Thirty-nine distinct plant megafossils were recognized from the clay-ironstone beds (Fig. 1, unit B; Table 1). The great diversity among the pteridosperms is in direct contrast to the near absence of lycopod elements. Twenty-four distinct plant megafossils were identified from among the specimens collected within the dark shale horizon (Fig. 1, unit E; Table 1). In many cases, poor preservation of these specimens made identification to species difficult or impossible. Conifer specimens require further study for specific taxonomic treatment.

TABLE 1

Fossil plants of the 7-11 mine, Columbiana County, Ohio.

Plant group/Plant	Clay-ironstone horizon	Dark shale horizon
Lycopsida		
Cyperites sp.	—*	X**
Lepidostrobophyllum spp.	—	X
Sigillaria brardii	—	X
Sigillariostrobus sp.	—	X
Sigillarian cone axis	—	X
unidentified strobili (2)	X	—
Sphenopsida		
Annularia asteris	X	X
A. radiata	X	—
A. sphenophylloides	X	—
A. stellata	X	—
Calamites suckowi	X	(?)***
cf. *Calamostachys* sp.	X	—
Sphenophyllum majus	X	—
S. oblongifolium	X	—
Calamitean diaphragm	—	X
Filicopsida		
Alloiopteris erosa	X	—
Asterotheca sp.	(?)	X
Danaeites emersonii	X	—
Pecopteris arborescens	X	—
P. candolleana	X	(?)
cf. *P. cyathea*	X	—
P. hemitelioides	X	—
P. lamuriana	X	—
P. miltoni	X	—
P. unita	X	X
Ptychocarpus	—	X
Spiropteris sp.****	X	X
Gymnospermopsida		
Pteridospermales		
Alethopteris sp.	X	X
Aphlebia sp.****	X	X
Cyclopteris orbicularis	X	X
C. trichomanoides	X	—
Lescuropteris moorii	X	—
Linopteris neuropteroides	X	—
L. munsteri	X	—
cf. *Megalopteris* sp.	X	—
Mixoneura sp.	X	—
Neuropteris heterophylla	X	X
N. ovata	X	X
N. scheuchzeri	X	(?)
Odontopteris aequalis	X	X
O. brardii	X	—
Sphenopteris cf. *elegans*	X	—
S. minutisecta	X	—
Taeniopteris lescuriana	X	—
T. newberriana	X	—
Cordaitales		
Artisia sp.	—	X
Cordaianthus spp.	—	X
Cordaites cf. *principalis*	X	X
Cardiocarpon spp.	X	—
Voltziales		
Gomphostrobus sp.	—	X
Walchia sp.	—	X
Walchiostrobus sp.	—	X
Other ovules		
Samaropsis sp.	—	X

*Looked for but not present.
**Present.
***Identification tentative due to poor preservation.
****May be assignable to either a filicopsid or a pteridosperm.

BIOSTRATIGRAPHIC SIGNIFICANCE OF CERTAIN PLANTS

The unexpected occurrence of a suite of plants, including *Sphenophyllum oblongifolium* (Fig. 3), *Pecopteris candolleana* (Fig. 5), *Danaeites emersonii* (Fig. 4), and *Odontopteris brardii* (Fig. 2), within the ironstone layers (Fig. 1, within unit B) is of biostratigraphic significance. These species have been proposed as stratotype indicators of upper Conemaugh and Monongahela strata (equivalent to rocks of Virgilian/Stephanian B-C age) in adjacent eastern regions of the Appalachian Basin (Gillespie and Pfefferkorn 1979). In addition, *Lescuropteris moorii* was considered by Darrah (1969) and by Read and Mamay (1964) to be diagnostic of upper Conemaugh to mid-Monongahela strata. The presence of these plants at the 7-11 locality prompts two observations: 1) that the stratigraphic ranges of these taxa need to be extended; and 2) that caution and flexibility must be exercised when trying to date or correlate rocks on the basis of "marker" megafossils.

The 7-11 walchian conifer (Fig. 6) replaces Darrah's (1969, 1975) Rennerdale, Pennsylvania specimens (Upper Conemaugh) as the earliest recorded occurrence of conifers in the Appalachian Basin region. In addition, the presence of *Sigillaria brardii* (Fig. 8) is notable; this species is more commonly encountered in uppermost Pennsylvanian and Dunkard (Permian?) deposits (Gillespie and Pfefferkorn, 1979).

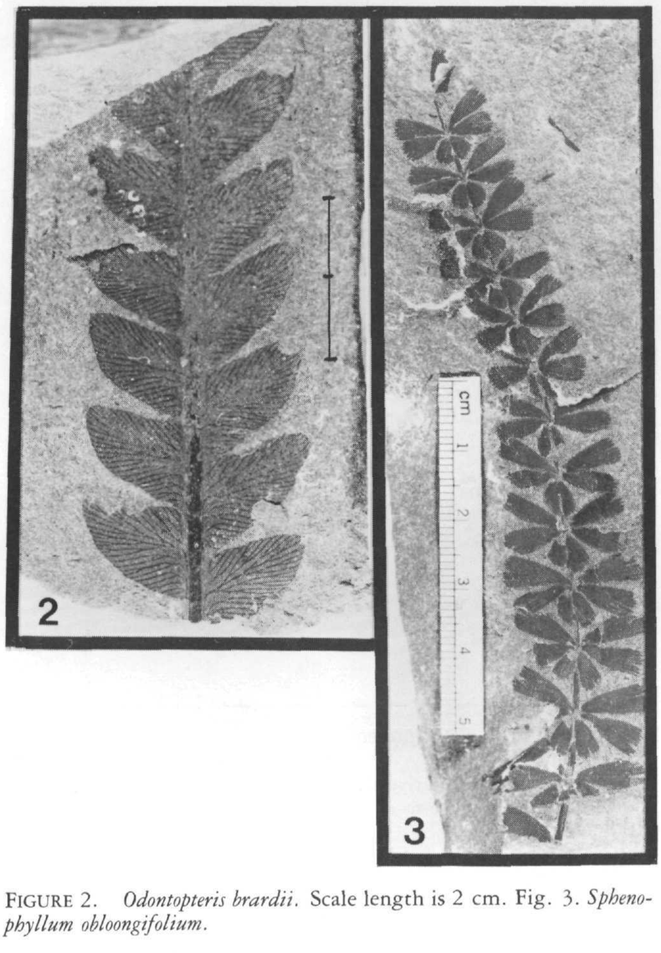

FIGURE 2. *Odontopteris brardii.* Scale length is 2 cm. Fig. 3. *Sphenophyllum obloongifolium.*

PALEOENVIRONMENTAL INTERPRETATION

The configuration of the 7-11 mine highwall reveals a paleotopographic low that appears to represent a low, broad channel of a cut-off meander, which eventually was maintained for a time as an oxbow lake. The fine-grained nature of the infilling sediments is notable. Morris (1967) recorded the absence of the coarse clastics in Upper Mahoning deposits of this region and the predominance of claystones and siltstones. Although geologists have recently identified mechanisms for generating clay-ironstone under marine conditions (Schutter 1983, Gastaldo 1985), the 7-11 model precludes a marine influence and invokes fluvial versus deltaic mechanisms. This hypothesis is supported by the absence of marine fauna in the section under study. The primary source of infilling sediments was the adjacent river. Initially, this was by restricted contact across the cut-off bar and later, after oxbow formation was complete, by flooding events.

Based upon currently accepted floral associations (Scott 1980, and references cited therein), the following environment is proposed for the clay-ironstone intervals. Several types of pteridosperms may have been growing on the levee banks, as well as on the adjacent floodplain together with marattialean tree ferns (*Pecopteris* spp.) and herbaceous ferns (*Alloiopteris, Danaeites*). Sphenopsids would be the expected colonists of the point bar adjacent to the restricted channel, and eventually would appear all along the margins of the established oxbow lake. Lycopod and cordaite elements probably grew in an adjacent, low-lying, swampy area of the floodplain. It is also possible that the cordaites preserved are representatives of a near-basinal environment slightly removed from the floodplain (Chaloner 1958). *Taeniopteris* (Fig. 7) has long been considered an upland floral element (Cridland and Morris 1963). In either case, it is possible that these three latter elements were introduced into the channel only in times of flooding. The greater amount of fern-like and sphenopsid foliage observed suggests their closer proximity to the channel.

With progressive cut-off of the meander channel, episodes of sediment influx would be limited to periodic flooding events. Silting-in of the quiet water body would have allowed colonization by plants and subsequent soil formation (equivalent to Fig. 1, unit C). Although it is impossible to deduce the exact nature of the associated flora, the drier nature of the immediate environment may well have permitted the gradual introduction of near-basinal elements such as conifers. It is postulated that local subsidence, perhaps from the gradual compaction and dewatering of the underlying barren shale sequence, was the mechanism responsible for a relative rise in water table. This condition was prerequisite to developing a coal-forming basin (equivalent to Fig. 1, unit D).

A continued rise in the water table would later inundate the swamp and initiate the lacustrine conditions associated with the formation of the dark shale horizon (Fig. 1, unit E). The dark shale sediments coarsened proximally to the lateral confining sands. A large portion of the lake sediments consisted of stagnant, carbonaceous muck. The presence of large conifer branching systems (up to 38 cm in length), some of which bear ovulate cones, as well as the bark, leaves, and cones of the lycopod *Sigillaria brardii,* suggest that these plants were growing close to and possibly overarched the lake (Scott

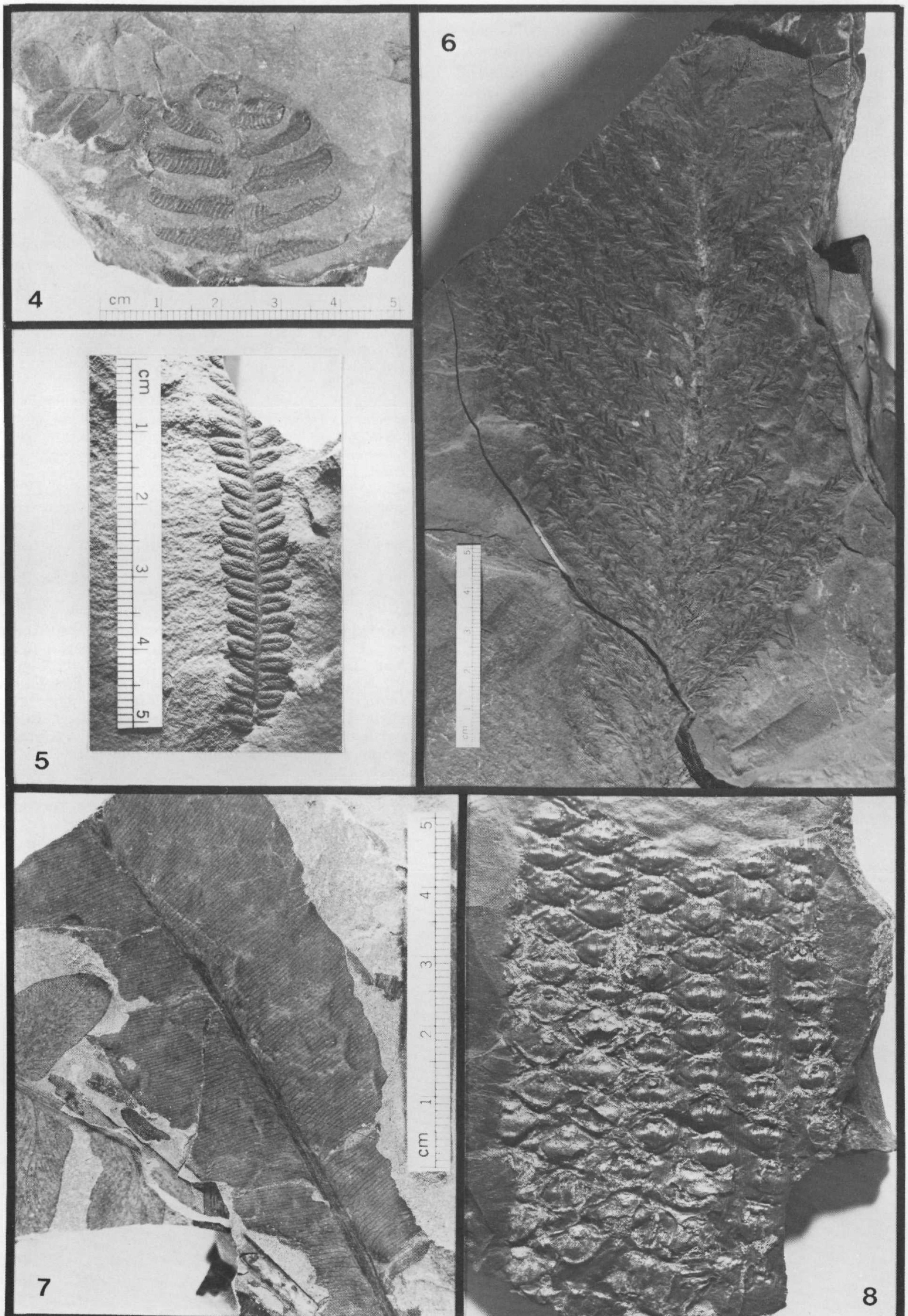

FIGURE 4. *Danaeites emersonii*. Fig. 5. *Pecopteris candolleana*. Fig. 6. *Walchia* sp. Scale length is 5 cm. Fig. 7. *Taeniopteris* sp. Fig. 8. *Sigillaria brardii*. X 1.1.

1979). Cordaite elements, which are ubiquitous within the unit, could represent lowland and/or near-basinal varieties encircling the lake. Pteridosperms and filicopsids, represented as a reduced number of fragmented, only moderately well-preserved specimens, probably inhabited the better-drained soils adjacent to the lake strand. The lack of pteridosperm ovules may either support this idea, or be a function of selective sorting and deposition. The general lack of sphenopsids is notable, as recognized lake margin assemblages typically include these elements (Scott 1979, 1980). Two possible explanations for their absence are as follows: 1) the lake strand was too muddy to support these plants and the few concentrated occurrences represent either "short-lived" colonization attempts or occasional, flood-related wash-ins of elements from drier lateral environments; 2) the number of fossils encountered may be a function of the exact site of sampling.

The contact between the freshwater, dark shale unit and the overlying Brush Creek (Fig. 1, unit F) is a sharp unconformity. Immediately above this contact, a poorly sorted, sandy lag (up to 15 cm in thickness) grades upward into dark-gray, limey, organic, marine shales of the Brush Creek. The lag deposit features a concentration of freshwater shark teeth and may represent a reworking of freshwater sediments.

CONCLUSIONS

Fossil evidence from the 7-11 exposure has extended the lower range of "marker" species *Sphenophyllum oblongifolium, Pecopteris candolleana, Danaeites emersonii* and *Odontopteris brardii*. Further study of the permineralized walchian specimens will provide insight into the physical nature and affinities of the oldest conifer thus found in the Appalachian Basin. The discovery of conifers in older rocks of this region is probable.

ACKNOWLEDGMENTS. This paper is a portion of a study done under the supervision of Dr. G. Rothwell, and is being submitted as a M.S. thesis, Ohio University, Athens, Ohio.

LITERATURE CITED

Chaloner, W. G. 1958 The Carboniferous upland flora. Geol. Mag. 95: 261 (Correspondence).

Cridland, A. A. and J. E. Morris 1963 *Taeniopteris, Walchia* and *Dichophyllum* in the Pennsylvanian System of Kansas. Univ. Kansas Sci. Bull. 44: 71-83.

Darrah, W. C. 1969 A critical review of the Upper Pennsylvanian floras of Eastern United States with notes on the Mazon Creek flora of Illinois. Gettysburg College, 220 pp.

———. 1975 Historical aspects of the Permian flora of Fontaine and White. *In:* J. A. Barlow and S. Burkhammer (eds.), Proc. First I. C. White Mem. Symp. Morgantown: West Virginia Geol. Econ. Surv., p. 81-101.

Gastaldo, R. A. 1985 Energy shale. *In:* L. C. Matten (ed.), Third Midcontinental paleobotanical colloquium, Guidebook, p. 1D-4D.

Gillespie, W. H. and H. W. Pfefferkorn 1979 Distribution of commonly occurring plant megafossils in the proposed Pennsylvanian System stratotype. *In:* K. J. Englund, H. H. Arndt and T. W. Henry (eds.), Proposed Pennsylvanian system stratotype Virginia and West Virginia. Amer. Geol. Inst., Sel. Guidebook Ser., No. 1, p. 87-96.

Kosanke, R. M. 1986 In press.

Krumbein, W. C. and L. L. Sloss 1951 Stratigraphy and sedimentation. San Francisco: W. H. Freeman.

Morris, D. A. 1968 Lower Conemaugh (Pennsylvanian) depositional environments and paleogeography in the Appalachian Coal Basin. Lawrence: Univ. of Kansas. Dissertation.

Phillips, T. L., R. A. Peppers and W. A. DiMichele 1985 Stratigraphic and interregional changes in the Pennsylvanian coal-swamp vegetation: environmental inferences. Int. J. Coal Geol. 5(1-2): 43-109.

Read, C. B. and S. H. Mamay 1964 Paleozoic floral zones and floral provinces in the United States. U.S. Geol. Soc. Prof. Paper 454K: 1-35.

Rice, C. L., T. M. Kehn and R. C. Douglass 1979 Pennsylvanian correlations between the Eastern Interior and Appalachian basins. *In:* J. E. Palmer and R. R. Dutcher (eds.), Depositional and structural history of the Pennsylvanian System of the Illinois basin, Pt. 2: Invited papers. Ninth International Congress Carboniferous Stratigraphy and Geol., Field Trip 9, p. 103-105.

Schutter, S. R. 1983 Petrology, clay mineralogy, paleontology, and depositional environments of four Missourian (Upper Pennsylvanian) shales of Midcontinent and Illinois Basins. Iowa City: Univ. of Iowa. Dissertation.

Scott, A. C. 1978 Sedimentological and ecological control of Westphalian B plant assemblages from West Yorkshire. Proc. Yorkshire Geol. Soc. 41(4): 461-508.

——— 1979 The ecology of Coal Measure floras from Northern Britain. Proc. Geol. Assoc., 90(3): 97-116.

——— 1980 The ecology of some Upper Palaeozoic floras. *In:* A. Panchen (ed.), The terrestrial environment and the origin of land vertebrates. London: Academic Press, p. 87-115.